Chapter 19
Analysis of Land Use/Land Cover Change Detection Using Remote Sensing and GIS of Fatehgarh Nau Abad Village, Bathinda, Punjab

Balwinder Singh and Chander Gagandeep Singh

Abstract Most of the Indian population is residing in villages to meet their basic necessities by cultivating agriculture as their main occupation. Land witnesses changes due to population increase and socio-economic activities, along with showing the sphere of influence of an urban centre on the nearby areas with the passage of time. As land use/land cover is dynamic in nature so, it becomes very important to understand how villages have changed and are changing its land use/land cover pattern at the micro-level. This research paper applied the potentiality of Remote Sensing and GIS to map, detect and quantify spatio-temporal land use/land cover changes by using the satellite images of Land sat (TM) of 1988, 1998 and high resolution images of 2008 and 2018 downloaded from Google Earth. The study was carried out in the village namely Fatehgarh Nau Abad of Bathinda District in Punjab. The different land use and land cover maps were prepared to analyze change detection of land use and land cover for the 4 distinct years covering the time period of 30 years, i.e. 3 decades. The result shows the decadal changes of land cover that the area under built up has increased from 16 (2.78%) to 39.51 (6.8%) in ha on non-built up land but there were also interchange of land between different land use and land cover categories in the study area. The developed spatial data base at the village level can be useful for rural planning, agriculturalists, and natural resource management.

Keywords Remote sensing · GIS · Land use · Land cover · Change detection

B. Singh (✉)
Department of Geography, Punjabi University Guru Kashi College, Talwandi Sabo, Bathinda, Punjab, India
e-mail: balwindersidhu67@gmail.com

C. G. Singh
Maharaja Ranjit Singh P.T.U., Bathinda, Punjab, India
e-mail: cgs.patiala87@gmail.com

19.1 Introduction

Agriculture is the main profession of the rural population residing in India to meet their basic needs. Increase in population and socio-economic activities are putting a burden on the land with the passage of time. It has become very important for properly planning, rational assessment and scientific utilization of every parcel of land. It becomes possible only if the whole complex of land use is studied at the district, tehsil or even village level by considering the conditions of local physical and socio-economic (Mohammed 1978). "The term *land cover* relates to the type of features present on the surface of the earth. The term land use relates to the human activity or economic function associated with a specific piece of land" (Lillesand et al. 2008). In other words, land use is the inclusive of natural environment for socio-economic purposes is changed, managed and modified into built up; while land cover is defined as the physical material (grass, tree, bare ground, etc.) at the earth surface. The interactions between land use and land cover attract the geographers to know it for longstanding time (Meyer and Turner 1996). The primary concern relevant to the geographer is to have insight of the prevalent relationship between the natural environment and the human being (Kumar 1986). The importance of land use mapping is felt in concern with evolution, better management, preservation, and conservation of natural resources of any area (Gangaraju et al. 2017). So, it becomes essential to know, to show and monitor the occurring trends in land use/land cover at the village level. For this, the modern technology of Remote Sensing and GIS is very effective, useful tool to analyze, detect the changes in land use/land cover by taking spatio-temporal data for the future planning of sustainable and management of natural resources. Application of remotely sensed data taken at different times made possible to study the changes in land use and land cover in less time, at low cost and with better accuracy (Kachhwala 1985) along with GIS software that provides the facility to analysis, update and retrieve data (Chilar 2000). This is better assessed as change detection is the process to identify differences in the state of any object or phenomenon by observing it from time to time (Singh 1989). It requires the comparison of two images of an area taken at different times for drawing land use and land cover changes. Prasoon and Pushpraj (2015) have analysed spatial and temporal distribution of land utilisation in Mopka village of Bilaspur city for studying changes in land use. Gangaraju et al. (2017) studied land use/land cover change detection in Pindrangi village. Rao et al. (2003) identified aquaculture hotspots at the village level. Mitra and Singh (2014) did land use/land cover mapping and change detection for a village. Wang et al. (2017) also used Remote Sensing and GIS to quantify changes of villages in the urbanizing Beijing metropolitan region.
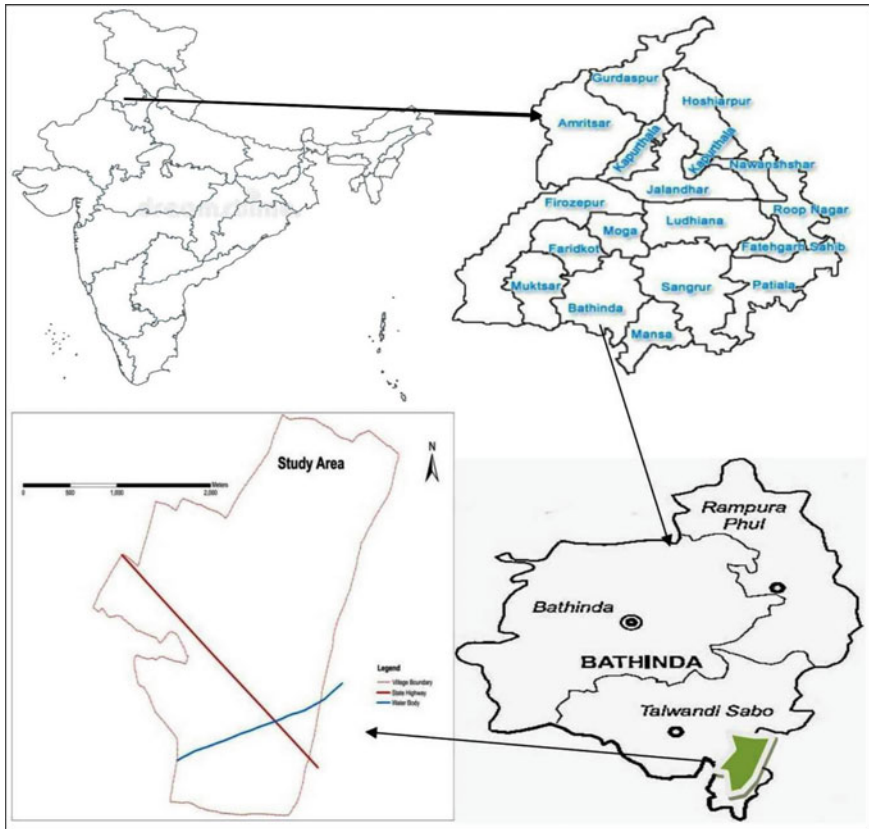
Fig. 19.1 The study area. *Source* India Map (www.dreamstime.com), Punjab Map (webindia123. com), Bathinda Map (onefivenine.com), and Study Area Map (by the authors)

19.2 Study Area

This present study was carried out in Fatehgarh Nau Abad village (Fig. 19.1), which falls under Bathinda District of Punjab state. It is located between 29° 58′32″ N Latitude and 75° 07′19″ E Longitude. It has total geographical area of 577.0 in ha. The population in the village is 1748 according to 2011 census. The village revenue boundary is surrounded by town Talwandi Sabo in the north, and by villages namely, Seikhpura in the east, Jaga Ram Tirth in the south, and Gurusar Jaga in the west. The main occupation of the village is agriculture. It is located four kilometres away south of Talwandi Sabo tehsil along the state highway. The town is a religious place and emerging as an educational hub having one private university and another in the study area with influencing socio-economic activities on the surrounding village land.

19.2.1 Objectives of the Study Area

The objectives of the study are

 (i) To prepare the different land use and land cover maps at the different time periods.
(ii) To analyse the change detection.

19.3 Methodology

19.3.1 Data Base

For the present study, the two images of Landsat (1988, 1998) and two of high resolution (2008, 2018) were downloaded from Google Earth in distinct years on decades. A Sentinel satellite image georeferenced (10 m spatial resolution) geocoded with WGS 1984, UTM zone 43 was also acquired from USGS earth explorer.

19.3.2 Ancillary Data

The Survey of India toposheet numbered 44 o/1 on the scale of 1:50 000 and cadastral map of the village Fatehgarh Nau Abad taken from concerned authority was also used.

19.3.3 Methodology

GIS open free software QGIS version 2.18.12 with GRASS 7.2.1 was used to geo-reference the Google earth data and cadastral map with the help of Sentinel georeferenced image and to extract village revenue boundary. Digitization-based on-screen and visual interpretation was performed to map land use/land cover in the form of polygons based on the geometric boundaries of each features and followed by field observation. Linear features such as road, branch of canal were shown as a buffer. As the spatial resolution of the Landsat images of 1988 and 1998 is poor and coarse. So, for the preparation of land use and land cover maps for 1988 and 1998, the infor-mation related to some features was collected by asking the information from the people of this village such as where and when was the area under sand dunes and orchards, when did they built their (isolated) houses and in which year religious, edu-cational institute, water works, dharmshala (community hall) and marriage palace came into existence by showing them high-resolution images of 2008 and 2018 to

mark polygons on the map during the field verification. The two images of different time periods were superimposed to show the changes in land use/land cover. The digitised data was quantified to get the area of each polygon. To show change detection during 1988–2018, the change matrix was also prepared for the study area.

19.3.4   Land Use and Land Cover Classification

The scheme for land use and land cover classification was devised to classify land use and land cover (Anderson et al. 1976; NRSA 2006). The adopted land use and land cover classification scheme for this study identified the 20 categories of land use/land cover namely crop land, orchard, vegetation, sand dunes, vacant land, branch of canal, pond, residential, educational institution, religious place, dharamshala (community hall), cremation/buried ground, water works, marriage palace, factory, shops, petrol pump, cart track (locally known as *pahi* leading to agricultural field), main road and link road.

19.4   Results and Discussion

19.4.1   Land Use and Land Cover

Land use and land cover for the different years was mapped to know the existing features related to 1988, 1998, 2008 and 2018 (Figs. 19.2, 19.3, 19.4 and 19.5).

19.4.2   Change Detection for Land Use and Land Cover

Change detection simply means to demarcate and determine an area of what is changing actually to what extent, by which one class of land use is changing into another over time period. The information extracted from the different four land use and land cover maps was analysed to show land use changes in the study area. There were no changes detected for the categories such as branch of canal 0.82 (0.14%), followed by pond 1.0 (0.17%), religious place 0.2 (0.03%), water works 1.6 (0.3%), cremation ground 0.69 (0.12%), main road 2.5 (0.43%), link road 4.15 (0.72%), and cart track 4.35 (0.75%) in ha.
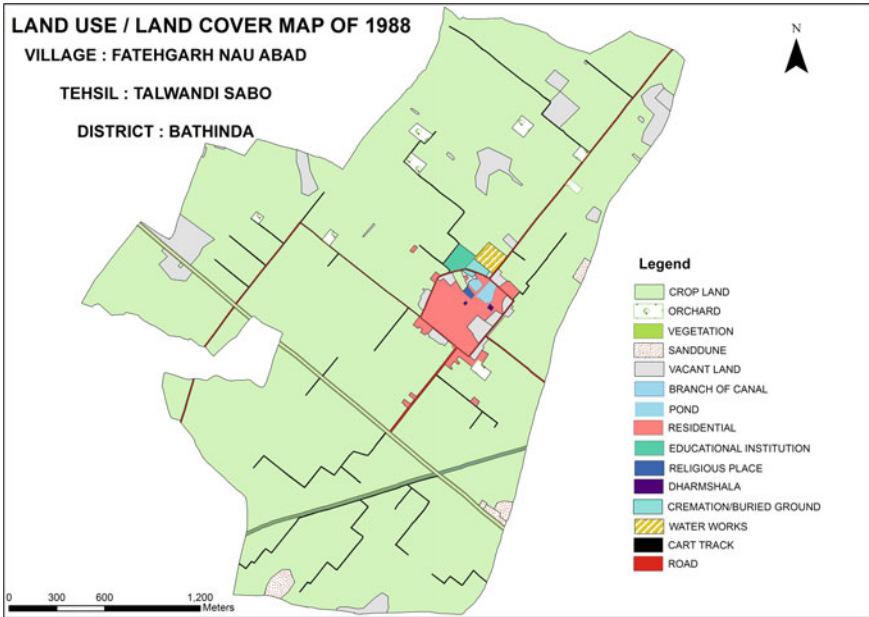
Fig. 19.2 Land use and Land cover map of 1988. *Source* prepared by the authors from Landsat (TM) Google Earth
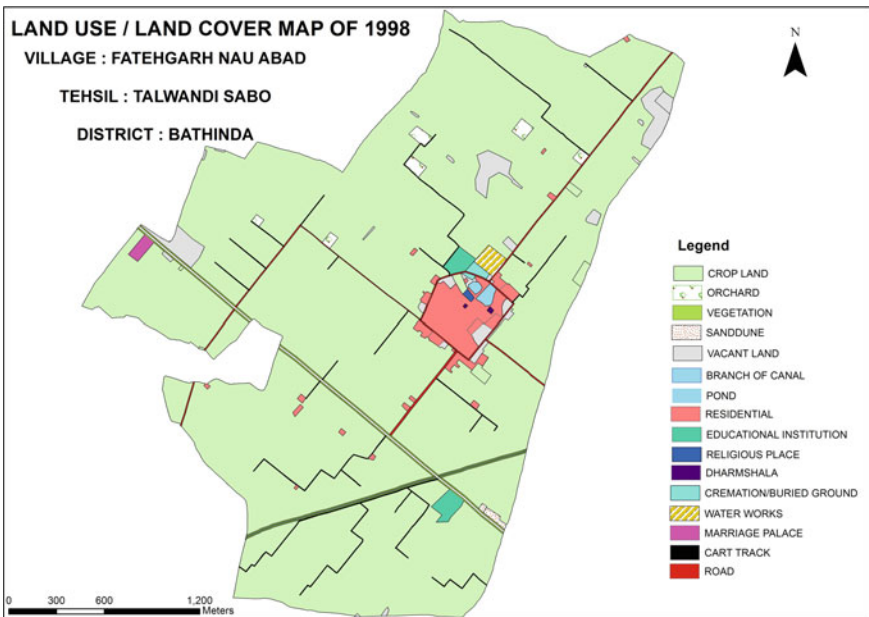

Fig. 19.3 Land use and Land cover map of 1998. *Source* prepared by the authors from Landsat (TM) Google Earth
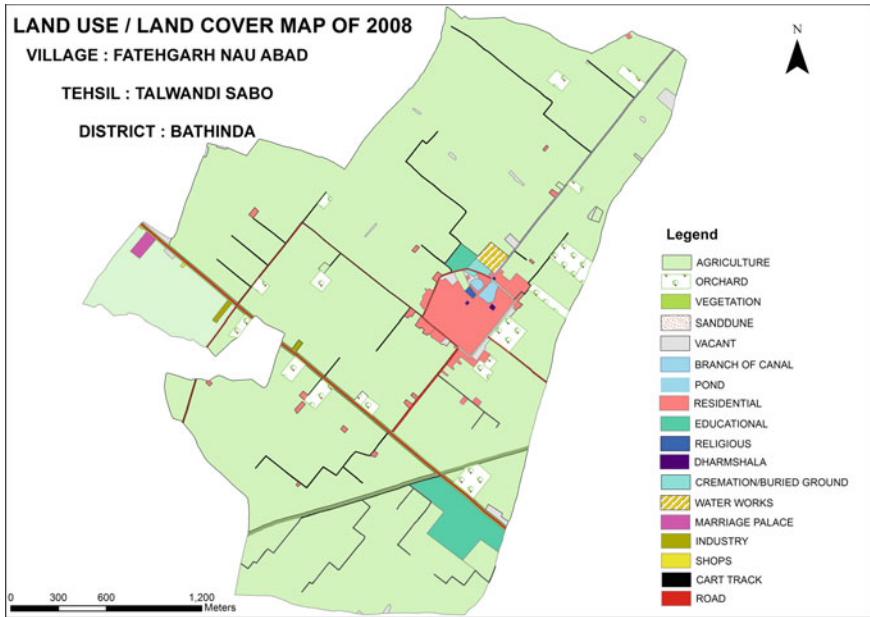
Fig. 19.4 Land use and Land cover map of 2008. *Source* prepared by the authors from Google Earth (High Resolution)
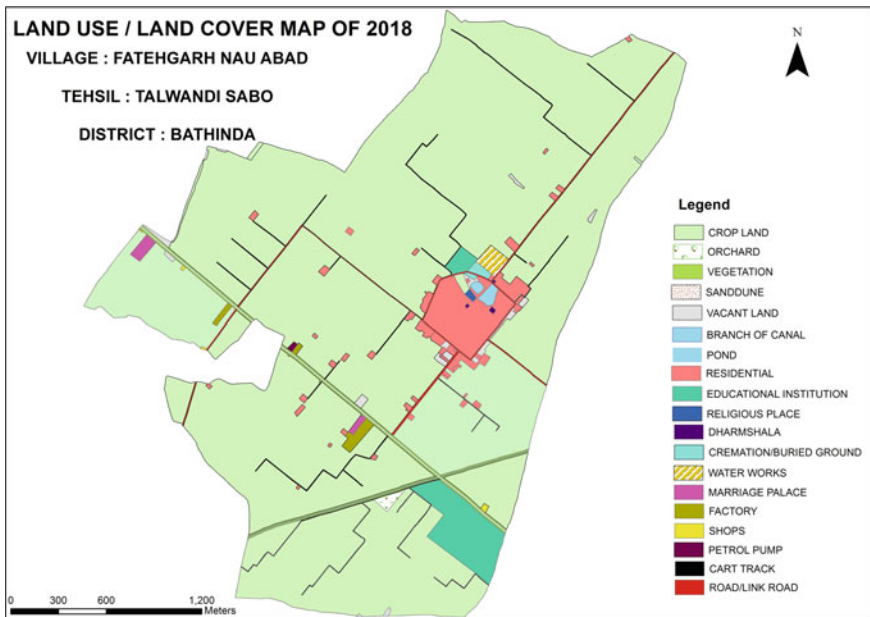

Fig. 19.5 Land use and Land cover map of 2018. *Source* prepared by the authors from Google Earth (High Resolution)

19.4.3 Change Detection for Land Use/Land Cover (1988–1998)

The categories of land use and land cover in the study area showed both increase and decrease in the total geographical area of 577 in ha (Table 19.1, Fig. 19.6). The total built up area in 1988 occupied an area of 16.0 ha (2.78%) consisting of residential (2.07%), dharamshala (0.01%), educational institution (0.24%), religious place (0.03%), water works (0.3%) and cremation/buried ground (0.12%). It increased to 21.09 ha around 3.66% in 1998. It is the addition/inclusive of the area under residential (2.07%–2.5%), educational institution (0.25–0.54%), marriage palace (0–0.15%), and along with the plus of the percentages of the rest categories in built up 1998. The area of crop land also showed an increase of 88.86–90.4% from the conversion of vacant land, sand dune and orchard land. While the other categories such as orchard (0.7–0.53%), vacant land (3.96–2.23%) and sand dune (0.63–0.12%) showed a decrease under their respective area during the time period of 1988–1998. In the change detection of land use and land cover, the total built up showed an increase of 0.87% with the addition/plus of residential (0.43%), educational institution (0.29%) and followed by marriage palace (0.15%). The area of crop land also increased (1.52%). Whereas the area under orchard (0.16%), vacant land (1.72%) and sand dune (0.51%) decreased.

19.4.4 Change Detection for Land Use/Land Cover (1998–2008)

The categories of land use and land cover in the study area showed both increase and decrease in the total geographical area of 577 in ha (Table 19.1, Fig. 19.7). The total built up area in 1998 occupied an area of 3.66% (21.09 ha) consisting of residential (2.5%), dharamshala (0.01%), educational institution (0.54%), religious place (0.03%), water works (0.3%), cremation/buried ground (0.12%), and marriage palace (0.15%). It increased to 33.04 ha around 5.7% in 2008 due to construction for educational purposes, economic activities and isolated settlements showing expansion of the village and the socio-economic influence of the nearby town on the village land. It is the addition/inclusive of the area under residential (2.5–2.93%), dharamshala (0.01–0.02%), educational institution (0.54–2.08%), factory (0–0.09%), shops (0–0.01%) and along with the plus of the percentages of the rest categories in built up 2008. The area under orchard also showed an increase of 0.53–2.74% from the conversion of crop land into orchard. While the other categories such as crop land (90.4–87.73%), vacant land (2.23–0.72%) and sand dune (0.12–0.006%) showed a decrease under their respective areas during the time period of 1998–2008. In the change detection of land use and land cover, the total built up showed an increase of 2.1% with the addition/plus of residential (0.43%), dharamshala (0.003%), educational institution (1.54%), shops (0.01%) and followed by factory (0.09%). The area

Table 19.1 Classification of land use/land cover and change detection

LU/LC categories		1988		1998		2008		2018		Change Detection					
										1988–1998		1998–2008		2008–2018	
		Hectares	%	Hectares	%	Hectares	%	Hectares	%	Hectares	%	Hectares	%	Hectares	%
BUILT UP(1–10)		16.0	2.78	21.09	3.66	33.04	5.73	39.51	6.8	5.09	0.88	11.96	2.1	6.54	1.1
1	Residential	11.96	2.07	14.44	2.5	16.92	2.93	19.12	3.31	2.48	0.43	2.48	0.43	2.2	0.38
2	Dharamshala	0.11	0.01	0.11	0.01	0.13	0.02	0.13	0.02			0.02	0.003		
3	Educational inst.	1.44	0.25	3.14	0.54	12.03	2.08	14.4	2.5	1.7	0.29	8.9	1.54	2.4	0.4
4	Religious place	0.2	0.03	0.2	0.03	0.2	0.03	0.2	0.03						
5	Water works	1.6	0.3	1.6	0.3	1.6	0.3	1.6	0.3						
6	Cremation/Buried ground	0.69	0.12	0.69	0.12	0.69	0.12	0.69	0.12						
7	Marriage palace			0.91	0.15	0.91	0.15	1.3	0.23	0.91	0.15			0.4	0.07
8	Factory					0.5	0.09	1.7	0.3			0.5	0.09	1.2	0.21
9	Shops					0.06	0.01	0.23	0.04			0.06	0.01	0.2	0.03
10	Petrol pump							0.14	0.02					0.14	0.02
11	Crop land	512.74	88.86	521.49	90.4	506.18	87.73	516.4	89.5	8.75	1.52	−15.31	−2.65	10.22	1.8
12	Orchard	4.0	0.7	3.08	0.53	15.8	2.74	0.56	0.09	−0.92	−0.16	12.72	2.2	−15.24	−2.6
13	Vacant land	22.84	3.96	12.9	2.23	4.14	0.72	2.7	0.47	−9.94	−1.72	−8.8	−1.52	−1.44	−0.25
14	Sanddune	3.64	0.63	0.7	0.12	0.04	0.006	0.04	0.006	−2.94	−0.51	−0.66	−0.11		
15	Vegetation	4.98	0.86	4.98	0.86	4.98	0.86	4.98	0.86						
16	Branch of canal	0.82	0.14	0.82	0.14	0.82	0.14	0.82	0.14						
17	Pond	1.0	0.17	1.0	0.17	1.0	0.17	1.0	0.17						

Table 19.1 (continued)

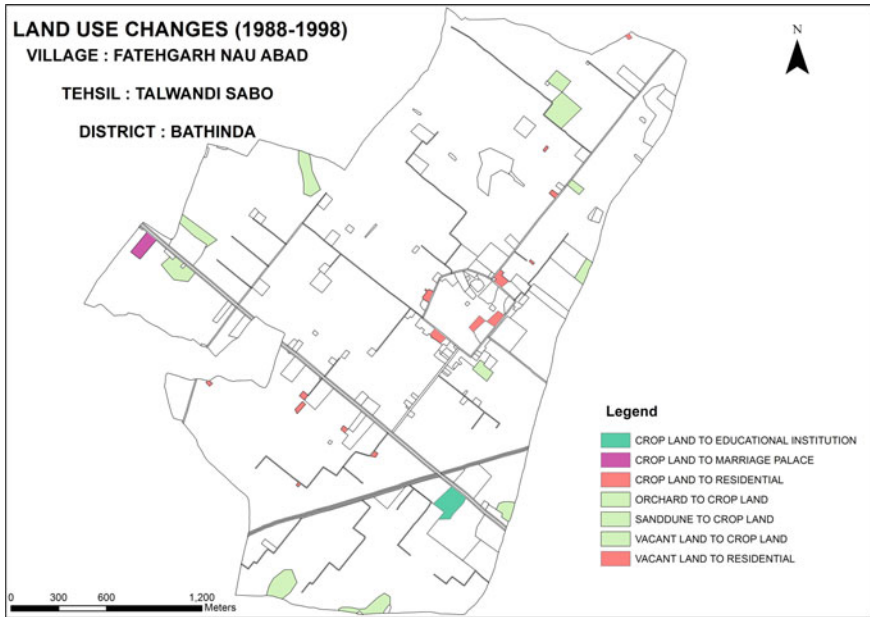| LU/LC categories | | 1988 | | 1998 | | 2008 | | 2018 | | Change Detection | | | | | |
										1988–1998		1998–2008		2008–2018	
		Hectares	%	Hectares	%	Hectares	%	Hectares	%	Hectares	%	Hectares	%	Hectares	%
18	Main road	2.5	0.43	2.5	0.43	2.5	0.43	2.5	0.43						
19	Link road	4.15	0.72	4.15	0.72	4.15	0.72	4.15	0.72						
20	Cart track	4.35	0.75	4.35	0.75	4.35	0.75	4.35	0.75						
	Total	577.0	100	577.0	100	577.0	100	577.0	100						

Source Prepared by the authors

Fig. 19.6 Land use changes (1988–1998) in the study area. *Source* prepared by the authors from Google Earth (Landsat TM)
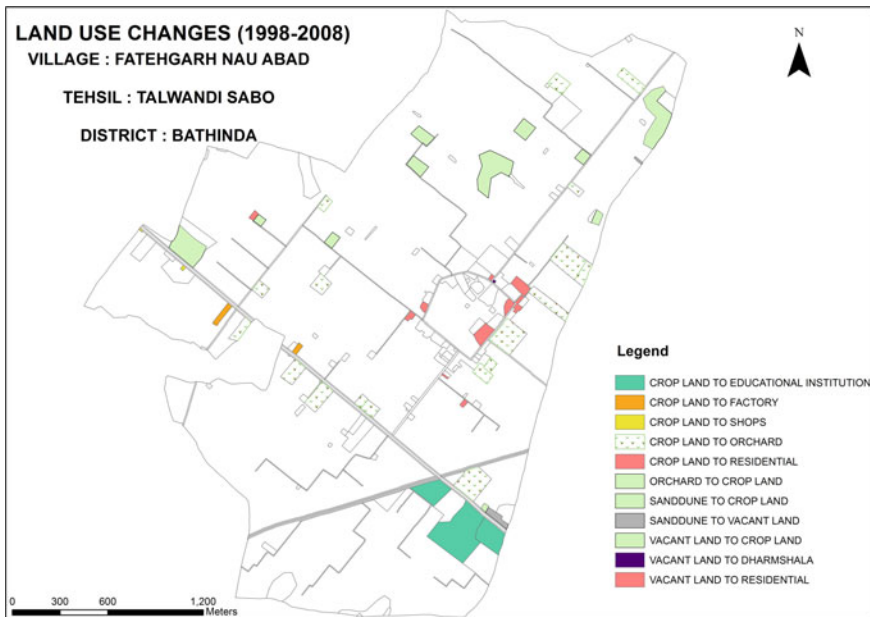

Fig. 19.7 Land use changes (1998–2008) in the study area. *Source* prepared by the authors from Google Earth (High Resolution)

of orchard also increased (2.2%). Whereas the area under crop land (2.65%), vacant land (1.52%) and sand dune (0.11%) decreased.

19.4.5 Change Detection for Land Use/Land Cover (2008–2018)

The categories of land use and land cover in the study area showed both increase and decrease in the total geographical area of 577 in ha (Table 19.1, Fig. 19.8). The total built up area in 2008 occupied an area of 5.73% (33.04 ha) consisting of residential (2.93%), dharamshala (0.02%), educational institution (2.08%), religious place (0.03%), water works (0.3%), marriage palace (0.15%), factory (0.09%), shops (0.01) and cremation/buried ground (0.12%). It increased to 39.51 ha around 6.81% in 2018 due to construction for expansion of educational institution, economic activities and isolated settlements showing the socio-economic influence of the nearby town on the village land. It is the addition/inclusive of area under residential (2.93–3.31%), educational institution (2.08–2.5%), marriage palace (0.15–0.23%), factory (0.09–0.3%), shops (0.01–0.04%), petrol pump (0–0.02%) and along with the plus of the percentages of the rest categories in built up 2018. The area under crop land also showed an increase of 87.73–89.5% from the conversion of orchard and vacant land.
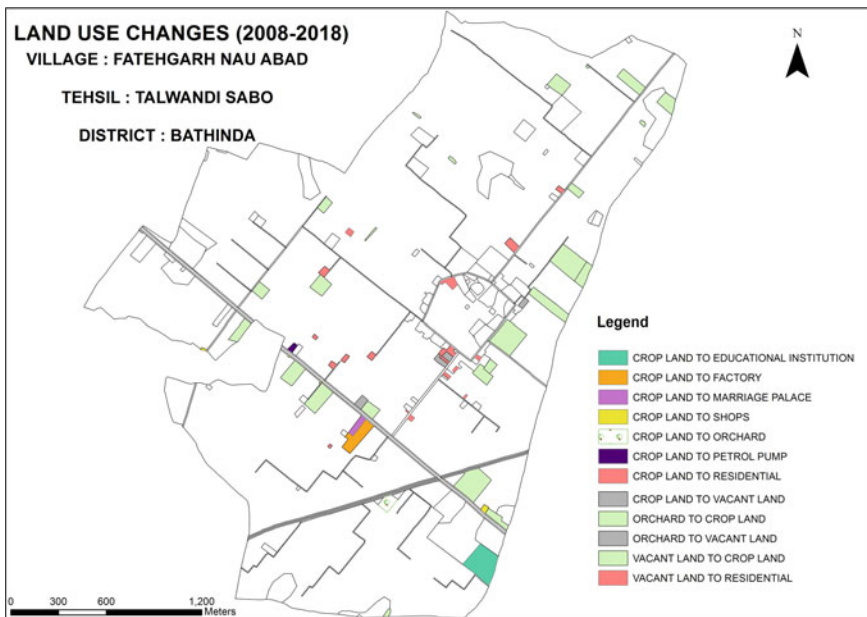

Fig. 19.8 Land use changes (2008–2018) in the study area. *Source* prepared by the authors from Google Earth (High Resolution)

Some of the vacant land was utilized for residential areas. While the other categories such as orchard (2.74%–0.09%), vacant land (0.72%–0.47%) showed a decrease under their respective areas during the time period of 2008–2018. In the change detection of land use and land cover, the total built up showed an increase of 1.1% with the addition/plus of residential (0.38%), educational institutions (0.4%), marriage palace (0.07%) and followed by factory (0.21%). The area of crop land (1.8%) also increased. Whereas the area under orchard (2.6%) and vacant land (0.25%) decreased.

19.5 Conclusion

This study carried out for analysis, monitoring of land use/land cover change detection in Fatehgarh Nau Abad village using Landsat and high resolution images of the different years like 1988, 1998, 2008 and 2018 download from Google earth reveals the result of important land use and land cover changes from 1988 to 2018 in the study area. The generated statistical data shows the changes of sand dunes, vacant land into crop land and crop land into orchard, vacant land and built up area. The total built up has increased from 16 ha (2.78%) in 1988 to 39.51 (6.8%) in 2018 for meeting the socio-economic needs of the area and is responsible for major land use/cover changes leading to encroachment on the village land toward or along the state highway (main road) due to expansion of the village and Talwandi Sabo town. This comprehensive spatio-temporal data can be useful for rural-planning, natural resources management at the micro-level.

References

Anderson JR, Hardy EE, Roach JT, Witmer RE (1976) A land use and land cover classification system for use with remote sensing data. Geological Survey Professional Paper 964

Chilar J (2000) Land cover mapping of large areas from satellites: status and research priorities. Int J Remote Sens 21(6–7):1093–1114

Gangaraju M, Anitha P, Krishna TV, Sravan KA (2017) Spatio-temporal changes of land use/land cover of Pindrangi village using high resolution satellite imagery. J Remote Sens GIS 6(2):1–4

Kachhwala TS (1985) Temporal monitoring of forest land for change detection and forest cover mapping through satellite remote sensing. In: Proceedings of the 6th Asian conference on remote sensing. National Remote Sensing Agency, Hyderabad, pp 77–83

Kumar J (1986) Land use analysis: a case study of Nalanda district. Bihar Inter-India Publications, New Delhi, India

Lillesand TM, Kiefer RW, Chipman JW (2008) Remote sensing and image interpretation. Willey, New York

Manual National Land Use Cover Mapping using Multi–temporal Satellite Data, NRSA, Hyderabad, May 2006

Meyer WB, Turner BL (1996) Land use land cover change: challenges for geographers. GeoJournal 39(3):237–240

Mohammed A (1978) Studies in agricultural geography. Rajesh Publications, New Delhi, India, pp 1–6

Mitra M, Singh S (2014) Land use land cover mapping, change detection and estimating at cadastial level through Remote Sensing and GIS application: a case study of Dhobi village, Hisar, India. Int J Geomat Geosci 5(2):357–361

Prasoon S, Pushpraj S (2015) A study of spatial and temporal distribution of land utilisation pattern in Mopka village using RS & GIS. Int J Agril Res Innov Tech 5(1):1–9

Rao KN, Krishna GM, Naik DR, Malini BH (2003) Remote Sensing and GIS applications in the identification of aquaculture hotspots at village level. J Indian Soc Remote Sens 31(2):71–80

Singh A (1989) Digital change detection techniques using remotely sensed data. Int J Remote Sens 10(6):989–1003

Wang K, Zhou W, Xu K, Liang H, Yu W, Li W (2017) Quantifying changes of villages in the urbanizing Beijing Metropolitan Region: integrating remote Sensing and GIS analysis. Remote Sens 9(448):2–16